ADVANCED FIRE PROTECTION DELUGE SYSTEM RESEARCH PROJECT

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ADVANCED FIRE PROTECTION DELUGE SYSTEM RESEARCH PROJECT

1. Introduction:

a. Energetic materials which burn or deflagrate pose a significant risk to munitions production, maintenance and renovation operations, as reflected by loses suffered by the U.S. Army Armament Munitions and Chemical Command between 1988 and 1992. These cost totaled $9,500,000 and involved three deaths, nine serious injuries, and severe property damage. Non-quantifiable costs included legal, environmental, investigation, lost production, and mandated improvements.

b. In Army ordnance facilities fire detection and suppression systems have not fully kept up with advances in new technologies. Many existing ultra high speed deluge systems were improperly designed and installed. Such problems have been identified and documented by accident investigation teams, surveys, staff assistance visits and project reviews. False alarms and activations have occurred with serious impact on ordnance operations. Response times of existing detectors is not consistent and may vary over a large range. The definition of deluge system response time is incomplete and not commonly agreed upon. Further complicating the existing situation is the lack of standardization guidance, performance standards and the loss of personnel qualified to design, install and maintain ultra high speed deluge systems.

2. Objective:

a. The objective of this effort is to develop and demonstrate an advanced ultra high speed fire protection deluge system that will provide a 95 percent reduction in false alarms and a 75 percent reduction in response time, compared to current systems installed at Army ordnance facilities.

b. In this project, the research effort is expanding on previous work. This includes the development of false alarm stimuli data which has caused significant problems with false activations of existing optical fire detectors, primarily UV (ultra violet). Validation and testing of new optical fire detector technology including dual band IR/IR (infrared), and IR/UV IR/IR as well as other new fire detection technology will eliminate many of these problems. False alarm stimuli tests were outlined in the test plan and conducted to assure that only the best performing "new" detectors are chosen for the prototype optimized system. The research effort also included validating the deductibility of pyrotechnic and propellant flash fires, designing, operationally testing and validating a prototype system, and foremost, introducing new and superior technologies which enhance the capability of the current systems to react faster to burning energetic materials. The feasibility of applying the new technologies developed by this project to tanks, armored personnel carriers, armored resupply vehicles and other armored vehicles will be examined, subsequently by the Army.

c. An additional objective of this project is the optimization of existing systems through upgrades, modifications, technical enhancements and operational procedures.

3. Approach:

a. One of the main goals of this project was to take advantage of the ideas and improvements that had been made by innovative plant technicians and engineers over the years. One of the suggestions was to locate the water and detector as close to the source of the burning hazard as possible, taking into consideration cost and safety. As a result of this thinking process, detectors, sphere and follow-on water were all placed over a test table at a minimum height of 36 inches. This would simulate a typical work station. For the larger amounts of material burns (1-3 pounds of pyrotechnic composition), the table is moved aside and the materials placed on the floor directly under the sphere. It is 71 inches from the bottom of the sphere to the floor. This configuration was designed to simulate a mixing operation. The sphere was placed on an adjustable rack to make adjustments as required to compensate for differences in propagation and burn rate of different materials.

(1) Off the shelf high rate discharge spheres were selected because it was believed that they could be successfully coupled with fast acting detectors and deliver water quickly and effectively to a burning hazard, since the location of the hazard was known. Two sizes are being tested; a 10 liter and 30 liter container. These spheres were selected because they can be pressurized with nitrogen to about 900 psi static pressure. An initial setting of 500 psi of nitrogen was selected and has been ideal throughout the evaluations to date. The spheres are discharged via an internal squib (actuator) activated by a signal from the detectors through a control panel. Because the exploding actuator creates internal pressure within the sphere, the water is discharged at about twice the static pressure. Thus, when a sphere is pressurized to 500 psi the water is expelled at about 100 psi of pressure. A screen and spreader break the water into small atomized particles, assure even distribution and collection of the residual fragments of the squib. A follow-on water system consisting of dual nozzle pressurized water assures additional cooling and suppression of the burning pyrotechnic or propellant hazard. In all tests conducted to date however, the sphere has successfully controlled and extinguished the burn without the supplemental follow-on water. The atomized water posed no hazard to personnel.

(2) Three dual band optical fire detectors are being tested based on their advertised characteristics as being false alarm resistant and ability to detect burning pyrotechnic materials in less than 5 milliseconds. They are: Spectrex 62002 (SAFE)-UV/IR, Fire Sentry (SS2-AM & SS2 AML)-UV/IR, and the Dual Spectrum Santa Barbara IR/IR. Detector Electronic UV optical fire detectors are also being used as a baseline. Most of the detectors presently used in Army ordnance facilities are Detector Electronics UV detectors. Although advertised as possessing false alarm resistance and ultra high speed characteristics, they have not been tested against these burning energetic materials as such materials are generally not available to private companies.

4. Testing:

a. The prototype system was tested with 1/4 to 1/2 pound samples of 8 different pyrotechnic compositions. They range from benign to very energetic compositions including smoke, first fire, illumination mixes and IR decoy flare composition. Each material was tested with each of the four detectors. The Detector Electronics units were used as a baseline for comparisons. Each test was repeated three times to ensure the results were statistically valid. Each sample was placed in pile. An electric match with several grains of smokeless gunpowder were used as an ignition source for the "burn". They were placed on the bottom of the pile. All tests with the 1/4 to 1/2 pound samples on the test table were conducted with the 10 liter sphere pressurized to 500 psi with 22 pounds (3 gallons) of water. Approximately 100 total evaluations were accomplished on the table.

b. The three dual band optical detectors and the UV Detector Electronics unit were subjected to extensive false alarm stimuli testing. These stimuli included floodlights, flashlights, neon drop lights, sunlight, chopped light (flood light and drop light sources), drill motor (with sparks), MIG and stick welding (mild steel, aluminum, stainless steel) with various currents and rods. Distances for welding operations included two, three, six, nine and twelve foot distances from the detectors. The UV detector was subjected to welding operations at distances beyond twelve feet including outside welding at over twenty four feet. False alarm stimuli testing was just completed. The results are still being analyzed. Detector performance comparisons will be addressed in the Phase I final report prepared by the U.S. Air Wright Laboratory Fire Research Section at Tyndall AFB, FL (WL/FIVCF).

5. Results:

a. All testing was conducted IAW the test plan. All tests were conducted using train Explosive Ordnance Disposal (EOD) and laboratory technicians. Extensive checklists were developed and followed. All tests were recorded on standard speed video and high speed video (1,000 frames per second) with a camera borrowed from the U.S. Army. Each event (test) was written up separately and the events recorded in a log book. Data recorded for each event included times from detectable event to sphere discharge, detectable event to sphere water on flame, detectable event to sphere water on table, detectable event to follow-on water and detectable event to fire suppression. All of the data was directly measured from observations recorded on the high speed camera and a data recorder. Test personnel also recorded observations in their field notes. Although each test was configured to test a particular detector's ability to "see" an event and activate the system, a measurement of how fast the other detectors reacted to the same event was also done.

b. In every test conducted the burning material was detected and extinguished by the proper system. In most cases considerable amounts of unburned residue remained on the table, lexan shield around the table and on the floor indicating that the system was catching and interpreting the burn before further propagation occurred. A few of the materials, however, were water soluble (smoke mixes for example) and dissolved in the residue water remaining from the

sphere. Each material burned produced varying response times for the system with energetic materials (red lead and M206 mix) producing the fastest response. The slower times usually occurred with the smoke mixes which partially obscured the detectors field of view. The smoke mixes also required more time to "ramp up" to an equivalent size fire of M206 IR flare mix, for example. One M206 IR flare fire grew to a diameter of 31 inches in less than two milliseconds. The same fire from a smoke mix would require 300 milliseconds to grow to this size.

c. Spectral analysis of the pyrotechnic materials and propellants will be conducted to determine the ultraviolet, visible and infrared spectral of eight different types of pyrotechnic compositions burning in a loose form for use in make adjustments to existing or designing new detectors for deluge systems. UV, IR, and visible spectral measurements will be performed using a water cooled CCD detector and spectrometer, These measurements will be performed in 300nm intervals. A fiber optic bundle will be used to collect light from the source to the spectrometer and it will allow for safe data acquisition. SIR-MIR measurements will be performed using a FTIR (Fast Fourier Transform Infrared Spectrometer) set up for emissions spectrum acquisition. Either a suitable fiber optic bundle or the equipment will be setup behind a shield using focusing mirrors to project the emission into the FTIR for safe acquisition.

6. Phase II Testing:

a. Phase II of this project will include testing with larger sample sizes up to 3-5 pounds. In addition to the materials on hand, additional types of pyrotechnic compositions and propellants will also be tested.

b. A final report will be prepared with details on the prototype system including drawings and specifications. A handbook on the design, installation, and maintenance of ultra high speed deluge systems will also be prearmed.